Research focus. The Southern Sierra Critical Zone Observatory (CZO) was established in 2007 as a community platform for research on critical-zone processes, and is based on a strategic partnership between the University of California and the Pacific Southwest Research Station (PSW) of the U.S. Forest Service. The CZO is co-located with PSWs Kings River Experimental Watersheds (KREW), a watershed-level, integrated ecosystem project established in 2002 for long-term research to inform forest management.

The conceptual science model for the CZO is built around bi-directional links between landscape/climate variability and water/material fluxes across the rain-snow transition. Ongoing research focuses on water balance, nutrient cycling and weathering across the rain-snow transition; soil moisture is an integrating variable.

Science questions currently being addressed include:

- How does landscape variability control how soil moisture, evapotranspiration and streamflow respond to snowmelt and rainfall?
- How is soil moisture linked to topographic variability, soil formation and weathering?
- What physiological mechanisms are controlling how vegetation distribution and function vary with climate?
- How do vegetation attributes influence cycling of water, energy, CO₂?
- What is the link between soil heterogeneity, water fluxes and nutrient availability?

Geography. The Southern Sierra CZO is located at elevations 1750-2100 m, across the rain-snow transition, in a productive mixed-conifer forest, with extended measurement nodes at elevations 400-2700 m. The main CZO site includes 3 headwater catchments with a dominant southwest aspect (37.068°N, 119.191°W).

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Geology and soils. Soils within the watersheds developed from residuum and colluvium of granite, granodiorite, and quartz diorite parent material. Soils are weakly developed as a result of the parent material’s resistance to chemical weathering and cool temperatures. Upper-elevation soils are at the lower extent of late Pleistocene glaciations. Shaver and Gerle-Cagwin soil families dominate the watershed. Soils are gravelly sand to loamy sand, with a sand fraction of about 0.75. Soils are shallow (< 50 cm) in parts of the watershed with low tree density and many rock outcrops. Soils in more gently sloping terrain with linear or convex hillslopes are moderately deep; and landforms with the deepest soils (>150 cm) supporting a high tree density.

Land uses. The area has a high forest density, with canopy closures up to 90%. PSW plans to thin and/or carry out controlled burns in two of the three headwater catchments of the CZO, to inform forest managers about impacts of thinning on ecosystem services. Five more nearby, similar headwater catchments are part of this USFS research. The area has limited recreational use, e.g., hunting and OHV use.

Contact. The Southern Sierra CZO PI is Roger Bales, rbales@ucmerced.edu. For more information, see https://snri.ucmerced.edu/CZO. The Southern Sierra CZO involves Co-PIs and students or postdocs from 8 campuses, with several additional collaborators. To join the CZO community, contact the PI or any of the Co-PIs.
Climate. The southern Sierra Nevada is a Mediterranean climate, and experiences relatively wet winters and dry summers. Annual average temperatures are about 8°C at the bottom and 1-2°C cooler at the top of the CZO catchments. These differences are driven largely by daytime temperatures, owing to cold-air drainage at night. Daytime winds are upslope and nighttime winds downslope, with wind speeds generally under 1-2 m s⁻¹. Precipitation averages about 120 cm per year, and is about 20-60% snow. Photosynthesis persists through the winter, and soils and regolith store enough water for photosynthesis to occur all summer. As soils dry out, trees apparently extract water from the deeper soils. Annual runoff is about 15-30% of precipitation in dry years, increasing to 30-50% in wet years. The ground is snow covered for 4-5 months each year, and may experience multiple melt events during the winter and spring.

Instrumentation. There are 2 meteorological stations, a 60-m flux tower, a 60-node wireless embedded sensor network, 215 EC-TM sensors for volumetric water content, over 110 MPS sensors for matric potential, 60 snow-depth sensors, meadow piezometers and wells, sap-flow sensors, stream gauges and water-quality measurements.

Signature data types. Level 2 data (cleaned, calibrated) from core field measurements are made available by water year. These include precipitation, energy balance, snow, stream flow, soil moisture, sap flow, temperatures, stream geochemistry, soil chemistry, flux-tower data, meadow water levels, vegetation, and various other characterization data sets. Current-year level-1 data are available by request. Investigator-specific data are available as per the NSF data policy. The area has multiple LIDAR coverages, and a variety of other data sets are available through PSW scientists. It is planned to locate a NEON aquatic package at the CZO, and three flux tower within the current elevational transect of 4 CZO towers.

Ecosystem types. The catchments are largely Sierran mixed-conifer forest, with some mixed chaparral and rock outcrops. Dominant trees are white fir (*Abies concolor*), ponderosa pine (*Pinus ponderosa*), Jeffrey pine (*Pinus jeffreyi*), sugar pine (*Pinus lambertiana*), incense cedar (*Calocedrus decurrens*) and black oak (*Quercus kelloggii*). Several species of shrubs are also present. Of the three perennial streams, one borders meadow over 90% of its length, one has no meadow and the third is intermediate.

Research highlights. The distributed snow and soil moisture measurements show a close coupling between snowmelt and soil drying in spring/summer, with systematic variability across elevation, aspect and canopy cover. Evapotranspiration (ET) decreased proportionally as soils dried, going from about 1 to 0.1 mm d⁻¹ over the summer. However, about half of the ET occurred after snow melted. Runoff increased with elevation, corresponding to decreasing temperature, more precipitation falling as snow, decreasing vegetation density and coarser soils. Nutrient hotspots in soils are important for nitrogen cycling, and do not necessarily correspond to preferential flowpaths for water. Annual erosion rates measured in headwater catchments are only 1% of long-term rates, with headcut and bank erosion dominating. Wireless embedded sensor networks that statistically sample the landscape variability has proven to be an economical, scalable approach to measurement design; this approach is being replicated at other locations in the Sierra Nevada.